SURGE-CURRENT-RESISTANT SEMICONDUCTOR DIODE WITH SOFT RECOVERY BEHAVIOR AND METHODS FOR PRODUCING A SEMICONDUCTOR DIODE

PRIORITY CLAIM

This application claims priority from German Patent Application No. 10 2009 047 808.6 filed on 30 Sep. 2009, said German Patent Application incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

Embodiments of semiconductor structures, in particular diode structures, which both exhibit soft recovery behavior and have a high surge current strength, and production methods therefor, are specified herein.

BACKGROUND

For freewheeling diodes used e.g., in frequency converters for motor control, it is desirable for said diodes to have a so-called soft recovery behavior during turn-off or changeover, that is to say during commutation. By contrast, it is often undesirable for the diodes to have a hard recovery or oscillation behavior of current and/or voltage during turn-off. In order to achieve a soft recovery behavior of the diode, the internal plasma distribution, that is to say the distribution of the concentration of the free charge carriers (electrons and holes), in the diode can be configured such that it is low at the anode side. A reduction of the plasma on the anode side is realized e.g. in Emcon diodes (Emitter Controlled diodes), MPS diodes (Merged PiN Schottky diodes) and CAL diodes (Controlled Axial Lifetime diodes). With the reduction of the plasma on the anode side, however, the anodal emitter efficiency is also reduced.

In the meantime it has been recognized that in a series of applications, in particular in traction technology, a high surge current strength of the components is additionally required. In specific operating states that are unintended but often unavoidable particularly in the event of relatively long operation (e.g. recharging of the intermediate circuit after a short circuit), high overcurrents can arise e.g. in the frequency converter on the input side. For power diodes having a high blocking capability, this means that they should momentarily tolerate very high currents in the forward direction. Moreover, it is typically expected that an electronic component can be switched off from a current amounting to a multiple of the rated current, without being destroyed. Destruction of the diodes by severe local heating, so-called hot spots, should also be prevented during overcurrent conditions. In addition, the switching losses during changeover are intended to be as low as possible.

The plasma concentration reduced on the anode side in the diode structures mentioned above is, however, as mentioned, tantamount to a low anodal emitter efficiency of the anode emitter. This results in a higher voltage drop in the case of overcurrent and thus impairs the surge current strength of the diode.

In order to achieve a high surge current strength, the SPEED concept was developed (Self-adjusting P-Emitter Efficiency Diode). A lightly doped p-type anode zone having a reduced p-emitter efficiency has additionally introduced into it highly doped p^+-type zones that inject charge carriers in the case of a high current, which is intended to result in a lower voltage drop in the case of overcurrent. The SPEED diode is intended to have both a soft recovery behavior and a high surge current strength. However, it has been found that SPEED diodes exhibit a distinctly low robustness even under moderate switching conditions.

The reverse recovery behavior thus deteriorates if the p^+-type zones are heavily doped. On the other hand, if the p^+-type zones are doped less heavily and/or their horizontal area proportion is kept small, the soft recovery behavior can be maintained, but the improvement in the surge current strength is only moderate.

This can constitute a serious problem primarily in the case of very steep commutation, where a dynamic avalanche breakdown can be the consequence, since the lightly p-doped sections of the Speed diode are partly compensated for by the hole current. In addition, the formation of a cathodal depletion zone in which destructive filaments can arise typically occurs more rapidly during turn-off from high currents. All attempts to produce a SPEED diode having simultaneously robust switching behavior have been insufficiently successful heretofore. Therefore, the SPEED concept has not been implemented commercially.

A further variant is the "emitter switched diode". It consists of sequences of a highly doped p^+-type zone and a lightly doped p-type zone. The current path to the lightly doped p-type zone is controlled by a MOS channel. In the case of a MOS channel opened by a positive control voltage, the current takes the path via the lightly doped p-type zone. The emitter efficiency is low and the plasma concentration on the anode side is also low. Without a positive voltage at the gate, only the highly p^+-doped zone is active, and the emitter efficiency is high. Both a high surge current strength and a soft recovery behavior can be expected in that case. The disadvantage of this structure, however, is the high manufacturing outlay and also the need for active control at the additional electrode. Therefore, hitherto it has likewise not yet been realized commercially.

SUMMARY

In accordance with one embodiment, a bipolar semiconductor component is provided. The bipolar semiconductor component includes a semiconductor body having a load pn junction, a first horizontal surface and a second surface, which runs substantially parallel to the first surface. A first metallization is arranged on the first surface and a second metallization is arranged on the second surface. From the first metallization to the second metallization, at least one current path runs in the semiconductor body only through n-doped zones.

In accordance with a further embodiment, a semiconductor diode having a dynamic anode emitter efficiency is provided. The semiconductor diode includes an anode structure having a plurality of p-doped anode emitter zones that are spaced apart from one another in each case by an n-doped channel zone, wherein the channel zones and the anode emitter zones are in ohmic contact with the anode metallization.

In accordance with a further embodiment, a semiconductor diode having an anode structure and a cathode structure is provided. The anode structure includes an anode metallization and a plurality of mutually spaced apart p-doped anode emitter zones in ohmic contact with the anode metallization. The cathode structure includes a cathode metallization, an n-doped contact region in ohmic contact with the cathode metallization, an n-doped buffer region electrically connected to the cathode metallization via the contact region and has a lower maximum dopant concentration than the contact